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Research Article

Diversity and abundance of orchids in Crocker Range Park, Sabah, Malaysia

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ABSTRACT. A study on the diversity of orchids was carried out in Crocker Range Park, Sabah, Malaysia. Twenty seven plots of 50 m x 10 m each were set up in three different forest types. Four environmental parameters, namely temperature, humidity, altitude and canopy cover were measured to determine their influence on the occurrence and diversity of orchids. A total of 149 species belonging to 33 genera were recorded. Old secondary forests had the most diverse orchid species compared to young secondary forests and primary forests. The number of individuals and species were significantly correlated (p=0.004, p=0.001) with altitude while humidity, temperature and canopy did not influence the species composition.

Keywords: Orchidaceae, Borneo, diversity, Crocker Range Park.

INTRODUCTION

The orchid family is one of the most fascinating and attractive plants found abundantly in Borneo's forests. Wood & Cribb (1994) noted that Borneo is well-endowed with orchids. Chan *et al.* (1994) reported that Borneo is the centre for many edible fruit genera but could equally be referred to as the "Orchid Island." Lamb (1991) estimated that as many as 2,500-3,000 orchid species occur in Borneo. This figure is equivalent to 10% of the world's orchid flora, 10-12% of the Malesian flora and 75% of the Malesian orchid flora. Of these, 30-40% is thought to be endemic to Borneo (Chan *et al.*, 1994).

The Crocker Range Park (CRP), which is the largest terrestrial park in Sabah, is blessed with high biodiversity in its forest ecosystem. The park is slender in shape; the northeast-southeast axis is about 110 km long and 15 km wide. The park area is 139,919 hectares, which is twice the area of Singapore and Kinabalu Park (Usui *et al.*, 2006). Crocker Range Park was established in 1984 and designated as a Forest Reserve under Forest Ordinance No.2 in 1969. CRP was converted to a state park in 1984 for the conservation of natural resources and ecosystem in the area. The park is mountainous and the vegetation consists of five zones of forest which were classified according to elevation. There are also pockets of secondary forests due to effects of human activities and forest fires (Nais, 2004; Usui *et al.*, 2006).

The park encompasses an ecosystem across five vegetation types: montane forest, lower montane forest, upper dipterocarp forest, hill dipterocarp forest and lowland dipterocarp

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forest (Nais, 2004). The diverse ecosystems of CRP promises a large number of orchids. However, during the Crocker Range Scientific Expedition in 2002, only 12 species from eight genera were reported by Rimi *et al.* (2002). Chan *et al.* (1994) listed 12 species from 11 genera from the park. These figures are not revealing and they do not represent the diversity of orchids in the whole of CRP. Other than these two surveys, there is no comprehensive study on the diversity of orchids in this park. Thus, the objectives of this study were to compare the diversity of orchid species between the primary forest, old secondary forest and young secondary forest in CRP and to study the relationship between orchid diversity with respect to several environmental parameters in established plots.

MATERIALS AND METHODS

Selection of study site

Three main forest types with nine study sites within the CRP were selected (Figure 1). The locations were chosen based on elevation and accessibility. The forest status, i.e relatively good primary forest (PF), old secondary forest (OSF) and young secondary forest (YSF), was defined according to the vegetation and period of disturbance in the park (Table 1).

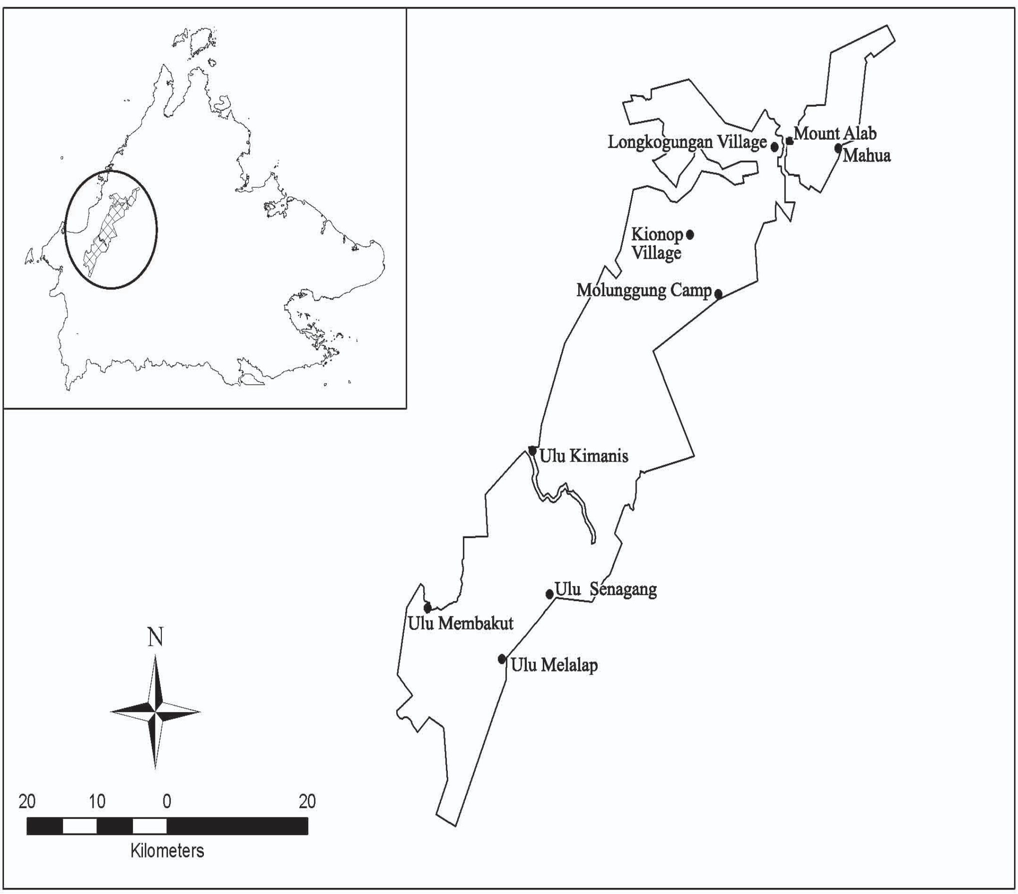

Figure 1: Map of Crocker Range Park showing location of sampling areas.

Table 1: The description of each study site based on forest types in CRP.

Forest Type	Locality	No. of Plot	Descriptions
Primary Forest (PF)	Mahua	3	Undisturbed forest
	Molunggung Camp	3	
	Mt. Alab	3	
Old Secondary Forest (OSF)	Ulu Kimanis	3	Had been disturbed 20-30 years ago or lightly disturbed
	Longkogungan Village	3	
	Kionop Village	3	
Young Secondary Forest (YSF)	Ulu Melalap	3	Had been disturbed 5-10 years ago or heavily disturbed
	Ulu Senagang	3	
	Ulu Membakut	3	

Plot Establishment

Three plots of 10 m x 50 m each were established randomly by selecting a point along the trail in each locality. In total, 27 plots were established (Table 1). The starting point of each plot was placed 10 m away from the main trail to avoid potential disturbance effect. In each plot, the number of individuals of every species was calculated and four environmental parameters were taken, namely altitude, humidity, temperature and canopy cover.

Data Analysis

Data obtained was analyzed by statistical methods using software package SPSS version 11.0. Post Hoc Test (ANOVA) was also used to analyze the significant differences between forest types towards species diversity richness and evenness. ANCOVA was used to analyze if there is significant difference between forest types towards the number of species and individual.

The species accumulation curve and species rank abundance curve were plotted using the *Species Diversity and Richness* version 2.0 software. The rank abundance curve was plotted to provide important information about the community which could be accessible at a glance (Molles, 2002).

The cluster analysis was used to classify similarities within environmental parameters from all the plots. This analysis was performed as a tree diagramme using Jaccard distance and the group average method.

Ordination was made on plots based on the environmental parameters of orchids. In this study, Principle Component Analyses (PCA) was used to ordinate the 27 plots based on the four environmental parameters. Ordination is a method for arranging sampling or experimental units in terms of species composition or environmental characteristics (Quinn & Keough, 2002). The PCA was carried out using the PC-ORD programme version 4.0 software.

RESULTS AND DISCUSSION

Species Richness

In total, 149 species of orchids were collected and recorded from CRP. A total of 85 species were recorded from PF, while 55 and 22 species were recorded in OSF and YSF, respectively. This was supported by the rank abundance curve. From the rank abundance curve, the longest tail is exhibited by PF, which indicates that it was more diverse than OSF and YSF in terms of species richness (Figure 2). The longest tail indicated that the number of species

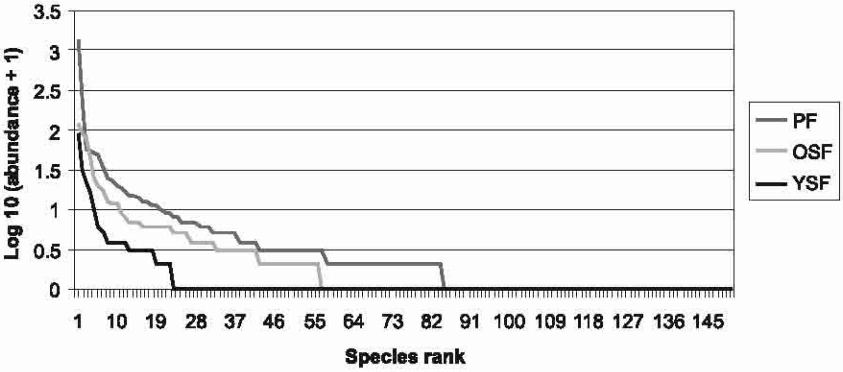

Figure 2: Rank abundance distribution of orchids in PF, OSF and YSF. The species was ranked in order from the most to the least abundant.

in PF was more abundant than OSF and YSF. The high abundance in PF was due to the number of individuals of *Dendrochilum muluense*. Based on observations, this species was widely distributed and at times there were more than 20 individuals growing on a single host tree. This species contributed 1,349 (61.9%) to total individuals within plots in PF. *Coelogyne radioferens* also contributed 234 individuals in a single plot of PF. This may explain that lower species diversity in the PF was due to a few species being dominant in the forest. Several species, however, have the same abundance in PF and OSF. In this case, the species abundance rank curves overlapped. The shortest tail was again from YSF and this shows a low species richness compared to the other two types of forests.

The species accumulation curve also supports the greatest number of species in PF. From the species accumulation curve, PF was leveled higher than OSF and YSF (Figure 3). This indicates that PF is most diverse in terms

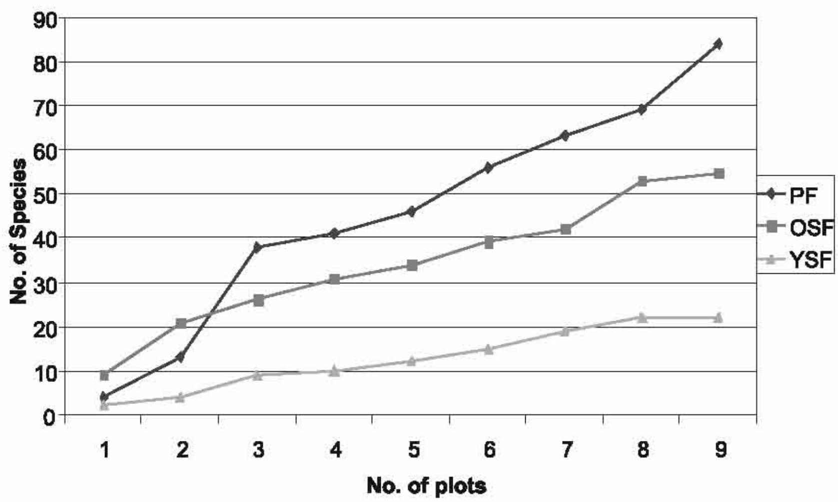

Figure 3: Species accumulation curves for PF, OSF and YSF.

of species richness. The curve for PF increased more rapidly than the other forest types and is still rising for the entire sample of the nine plots. This shows that there might be orchid species that were not collected in this study. At the beginning, it was shown that the steepest curve appeared from the samples of PF. It shows that this forest type accumulated higher number of species in a shorter time than the other forest types. There is a probability of this curve shifting higher if the sampling area is extended. The OSF curve increased in the beginning and slowed down towards the end of sampling and seems to be leveled off. The curve for YSF increased slowly and leveled off at plot 8 and 9.

Further analysis showed that the orchid species richness was not significantly different among forest types (ANCOVA, df = 2; p 0.606) but significantly different between altitudes (Spearman's rho; p= 0.004).

Shannon-Weiner Diversity and Evenness Indices

The Shannon-Weiner index (Figure 4) shows that OSF had the most diverse orchid species among the three forest types (H' = 2.88). This was due to evenness, where the population of orchids from OSF was more even than the other forest types. Even though the PF yielded the highest number of species and individuals, the population of orchids was not even. This affected the value of H', which was lower than the OSF. However, when ANOVA (Post Hoc Test) was used to compare the mean of the diversity indices between the three forest types, the difference was statistically significant (df = 2, P 0.05).

The evenness trends were similar (Figure 4). OSF had higher evenness whereas PF had low evenness. However, when ANOVA was used to compare the evenness index between forest types, the difference was not statistically significant (df = 2, p > 0.05).

According to Morrison (1998), the increased number of species found in a forested area is associated with additions of different habitat types. The diversity in a secondary forest should therefore be lower than in a primary forest. However, in this study, orchids of OSF were found to be more diverse than those PF and YSF. This finding is one example where diversity is lower in a primary forest than a secondary forest. There is no published data on orchids diversity in primary and secondary forests in Malaysia to compare with present findings.

Although the vegetation at OSF in this study was disturbed, orchid diversity was still high. Mount Alab, which is a primary forest, has much lower species diversity than Kionop

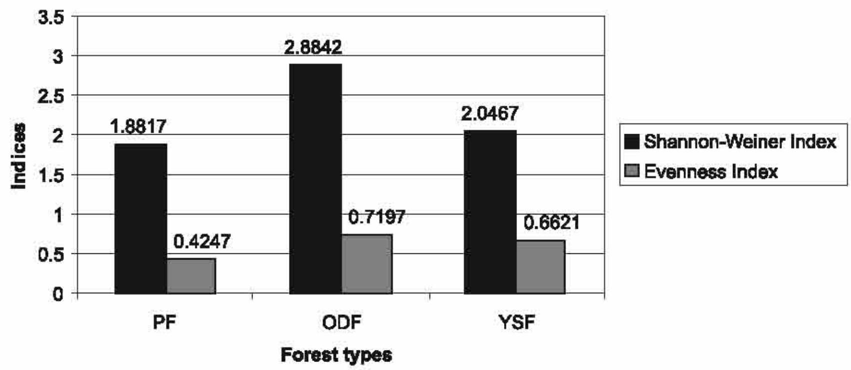

Figure 4: Shannon Weiner Diversity and Evenness Index of orchids in different forest types of Crocker Range Park

Village (OSF). This may due to illegal harvesting of wild orchids. It has been observed that the local people at Mount Alab area sell wild orchids to the public along the Kota Kinabalu-Tambunan road. They normally collect orchids in or around the CRP. This activity is one of the many reasons why the diversity of orchids is low in PF. Over collecting of certain orchids with beautiful flowers has influenced the plants' diversity, especially rare species.

The orchids in OSF had a more even distribution than in the PF. According to Magguran (1998), high evenness indicates high chances of finding any given species in a particular area. Therefore, orchids in OSF are considered to be more diverse because the distribution of every species is more even. In this study, OSF has higher orchid diversity because of its high evenness. Orchid plants in OSF were easy to find compared to PF and this explains why illegal collection of attractive orchids species for commercial purpose was rampant.

Cluster Analysis

Cluster analysis was used to classify the similarities between environmental parameters and the 27 plots in CRP (Figure 5). The dendrogram shows 24 chains with three large groups. The first group consisted of mainly plots from PF and four plots from OSF, namely OS2, OS4, OS5 and OS6. Therefore, the second group included mainly both OSF and YSF except for YS2, YS3 and YS6. The third group was formed from PF (PF4 and PF6) and YSF (YS2, YS3 and YS6).

In this study, classification of the plots based on environmental parameters showed that the samples from PF are clustered separately with samples from OSF and YSF (Figure 5). This implies that the measured environmental parameters can differentiate samples into either PF or OSF and YSF. Nevertheless, a few samples from PF and OSF were seen grouped together which indicated that certain samples have similar environmental conditions. For example, plots OS2, OS4, OS5 and OS6 in the OSF were constantly grouped among the samples in the PF. Therefore, the influence of environmental parameters in these plots cannot be guaranteed as OSF, but otherwise similar to the PF. Thus, it also implies that areas in the Longkogungan Village (OSF) are perhaps a primary forest. Although it has been disturbed in the past, the natural regeneration process in that area is now close to having the characteristics of a primary forest. Hence, the temperature, humidity and canopy cover in certain areas of OSF and PF were similar.

Principle Component Analysis (PCA)

PCA extracted four components of variation from the four selected environmental parameters. The first two principal components from PCA generated 90% of the variation. The weightings of variables contributing to each of the component are shown in Table 2.

The ordination (PCA) based on environmental parameters showed scaling plots in three forest types. The PCA plot shows four groups that correlate to environmental parameters. The young secondary forest (YS) formed two groups: (i) located on the upper, left side of the plot (YS2, YS3 and YS6); these plots correlated with higher temperature but lower altitude and canopy cover, and (ii) located on the bottom, left side; these plots were correlated with lower temperature, altitude and canopy cover. The old secondary forest plots also formed two groups near the horizontal axis: (i) located at the left side (OS1, OS3, OS7, OS8 and OS9) which were correlated with lower altitude, and (ii) located at the right side of the plot (OS2, OS4, OS5 and OS6); these plots were correlated with high altitude and canopy cover (Figure 6). Primary forest plots were located at the right side and sometimes overlapped with some plots from old secondary forests. Plots PF2, PF3, PF7, PF8 and PF9 that were located on the upper right side were correlated with high altitude. PF1, PF5, OS2, OS5 and OS6 plots were grouped on the bottom side of the plot and were correlated with higher altitude but lower temperature. Another environmental parameter was humidity which did not seem to affect the distribution of orchids in this study.

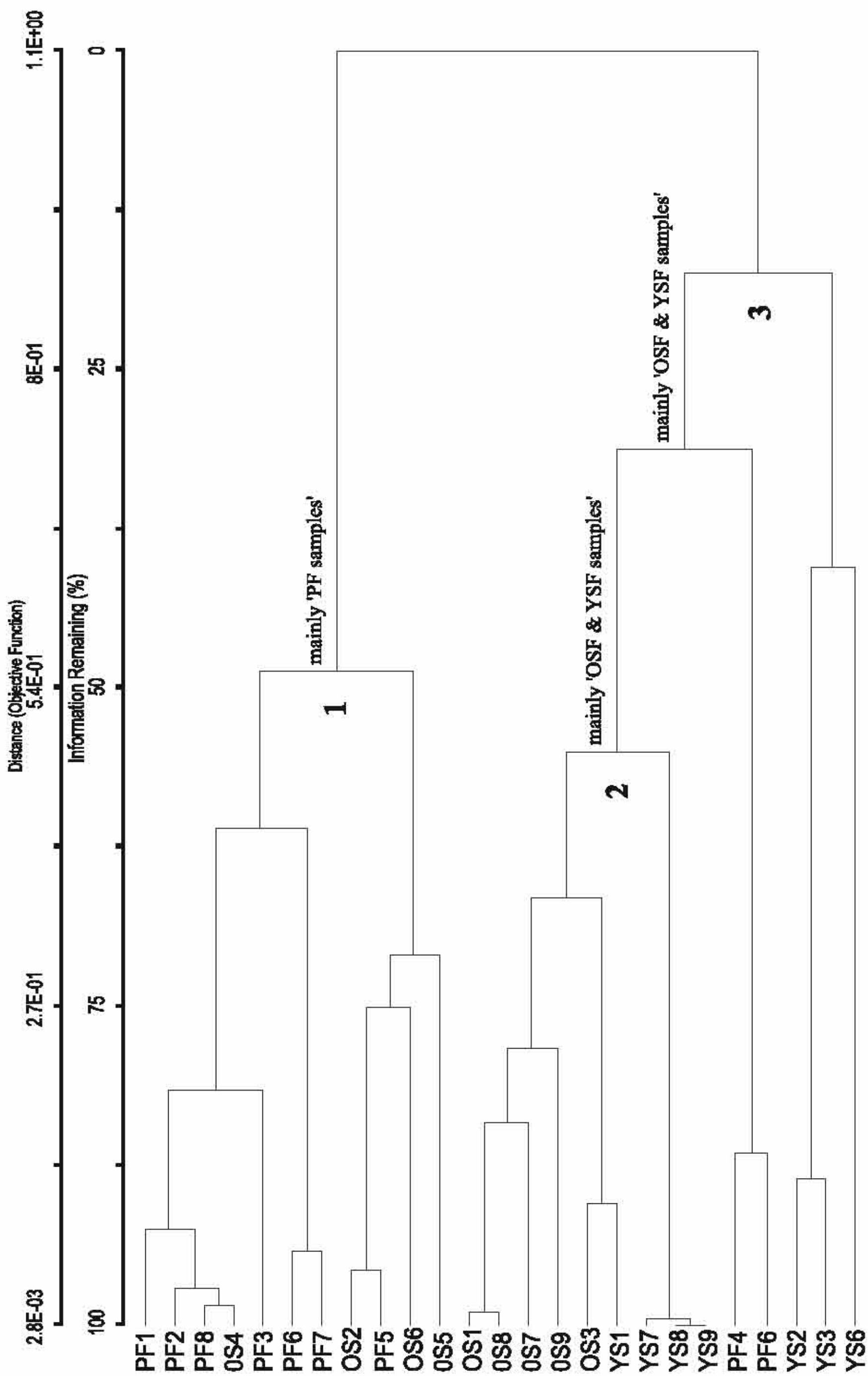

Figure 5. A dendrogram from the cluster analysis using environmental parameters data.

Table 2: Percentage of variation explained by four factors extracted by PCA

	Comp. 1	Comp. 2	Comp. 3	Comp. 4
Eigenvalues	2.369	1.251	0.290	0.089
Percent of variance	59.234	31.278	7.261	2.227
Cumulative % of variance	59.234	90.512	97.773	100.00
Parameters:				
Altitude	0.6129	0.1967	0.2146	0.7346
Temperature	-0.6079	0.1336	-0.4861	0.6135
Humidity	-0.2744	-0.7702	0.4974	0.2899
Canopy cover	0.4237	-0.5918	-0.6858	0.0053

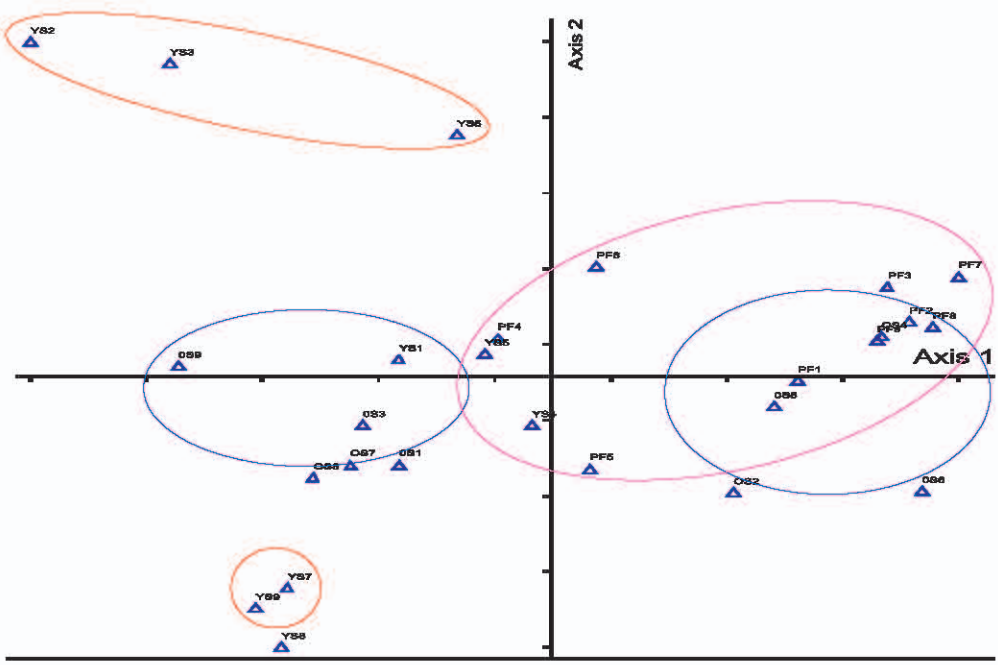

Figure 6: PCA scaling (ordination) plots of three forest types based on environmental parameters. PF (primary forest), OS (old secondary) and YS (young secondary).

Similarly, classification of all plots based on environmental parameters showed that OS2, OS4, OS5 and OS6 plots are grouped together with the PF plots. This result is also supported by the result of the PCA. The samples in PF and OSF were distributed at the right side and near the horizontal axis respectively, and sometimes overlapped one another. Samples in YSF, however, were grouped separately with PF and OSF. Furthermore, the PCA of environmental parameter showed that a few plots from the PF and OSF were very close to each other. This implies that the parameters in those plots are quite similar to each other.

The summary of the PCA components 1 and 2 shows 90.5% of the variation of the parameters condition in PF, OSF and YSF at CRP (Table 2). It can be suggested that component 1 is related to altitude while component 2 is related to temperature. Thus, in the PCA most of the plots in PF are weighted more to the right axis which is strongly correlated to altitude.

CONCLUSIONS

The orchids diversity in Crocker Range Park (CRP) was different among the three forest types. Old secondary forests had the highest orchid diversity, followed by young secondary forests and primary forests. This study also found that altitude has an influence on the diversity of orchids while, humidity, temperature and canopy cover were found not to influence orchid population. The total number of orchid species collected in CRP was 149 in 33 genera.

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